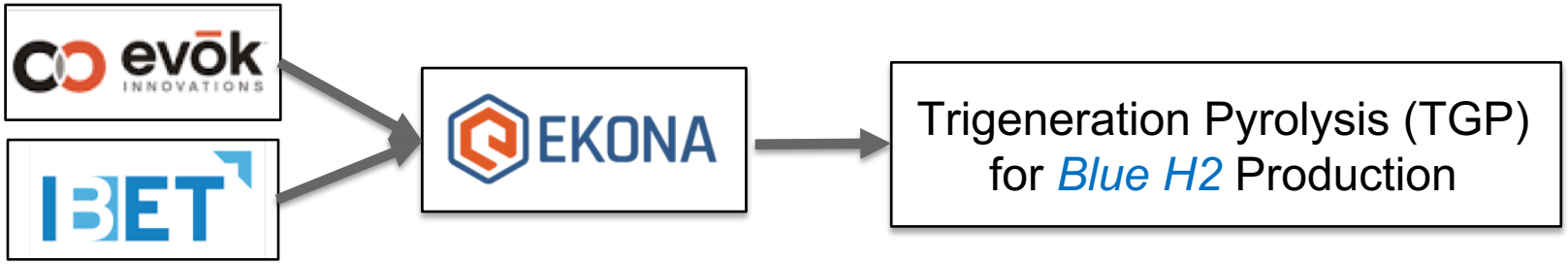
# Ekona's Tri-Generation Pyrolysis (TGP) Solution for Blue Hydrogen Production

December 2019

# Ekona Power Inc.

## Developing a novel *pyrolysis* platform for H2 production

- *Clean* - 90% fewer GHG emissions than incumbent SMRs
- *Low-cost* - Cost parity or better with incumbent SMRs
- *Scalable* - Suitable for large-scale, centralized industrial applications

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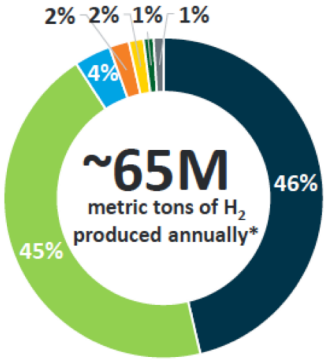
# Markets

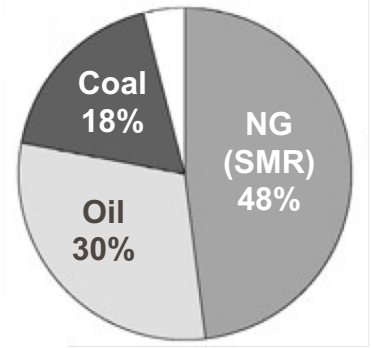
## Industrial H2




### Global H2 Markets

- Petroleum Recovery & Refining
- Ammonia Production
- Methanol Production
- Metal Production and Fabrication
- Electronics
- Food Industry
- Other

Electrolysis – 4%




### GHG Emissions

- 673 Mt-CO2e/year
  ~ 1.3% of global GHG's

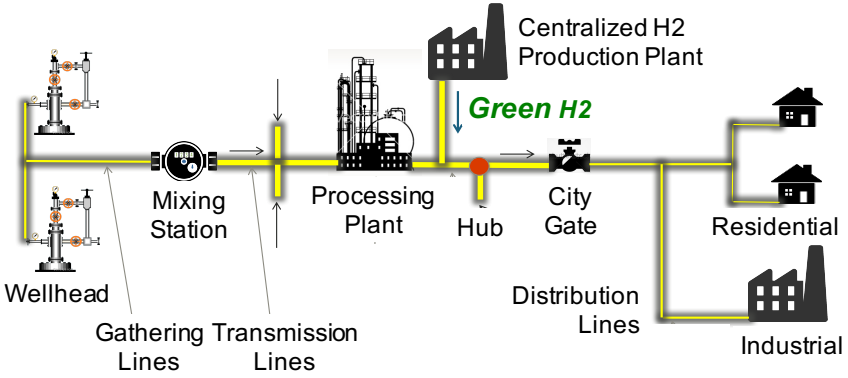
### H2 Production Cost

- SMR: $1.20/kg-H2
- SMR + CCS: $2.00/kg-H2

### Market Size

- Canada: 4 Mt-H2/year
- NA: 15 Mt-H2/year
- Global: 65 Mt-H2/year

## NG Decarbonization




10% H2 (vol.) is currently feasible with existing NG pipelines and appliences

Downstream GHG Emission Reduction:

3.6%

### GHG Emissions *(downstream)*

- 6,600 Mt-CO2e/year
  ~ 13% of global GHGs

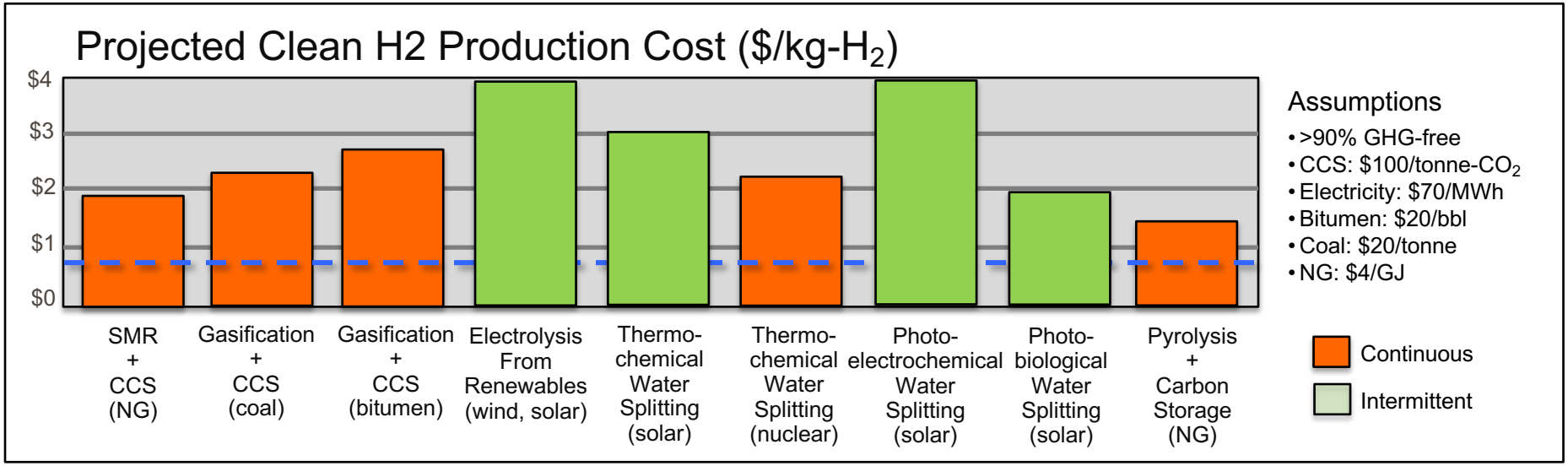
### Target Energy Supply Cost

- NG + $50/t CO2 levy = $7/GJ
  ~ $0.85/kg-H2

### Market Size (10% H2 vol.)

- Canada: 1.3 Mt-H2/year
- NA: 7.6 Mt-H2/year
- Global: 36 Mt-H2/year

# Technology Analysis



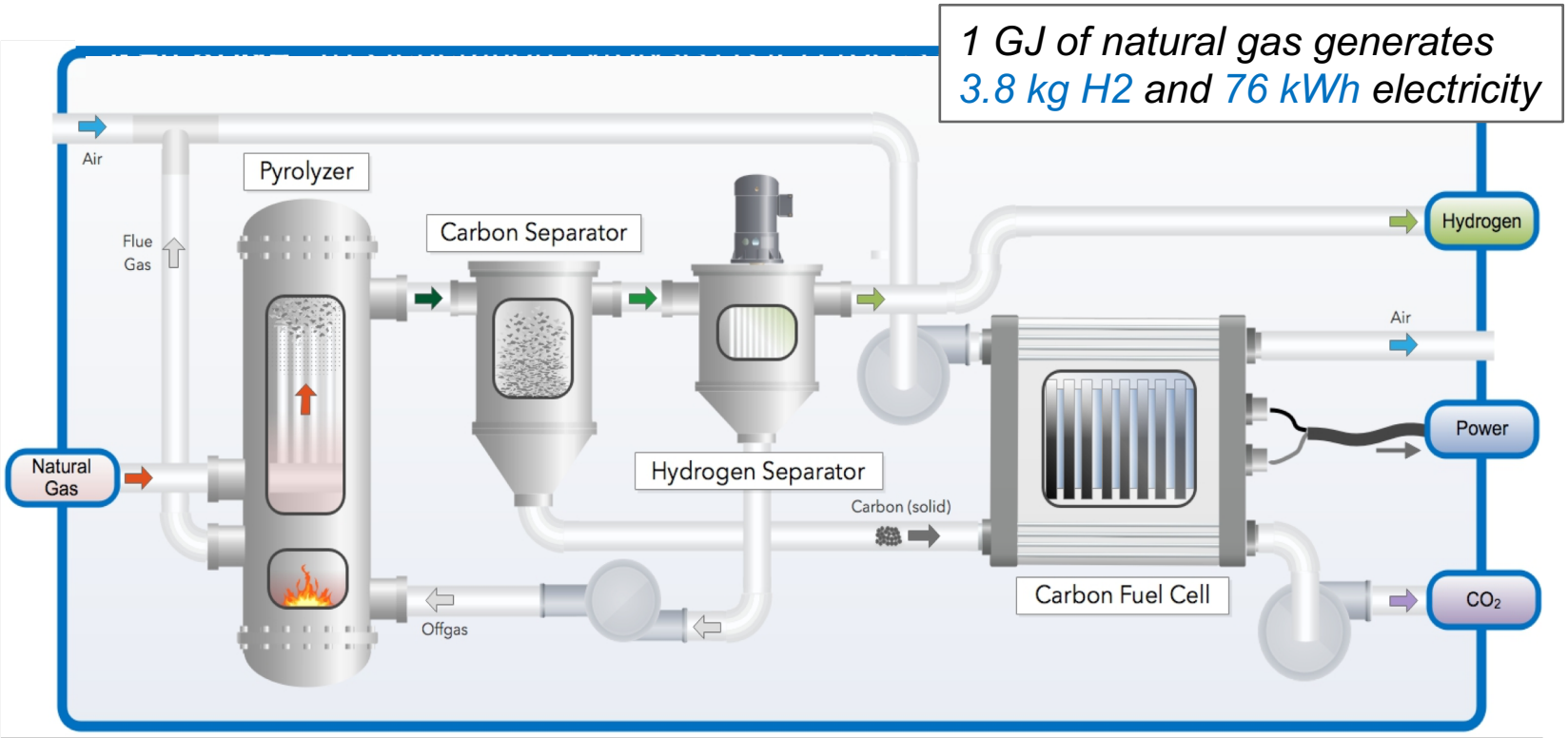

*Breakthrough Requirements*

- *Industrial H2 Production: Continuous, large-scale*
- *Cost Target: $0.85/kg*
- *GHG Emissions Reduction Target: 90%*

*Breakthrough Drivers*

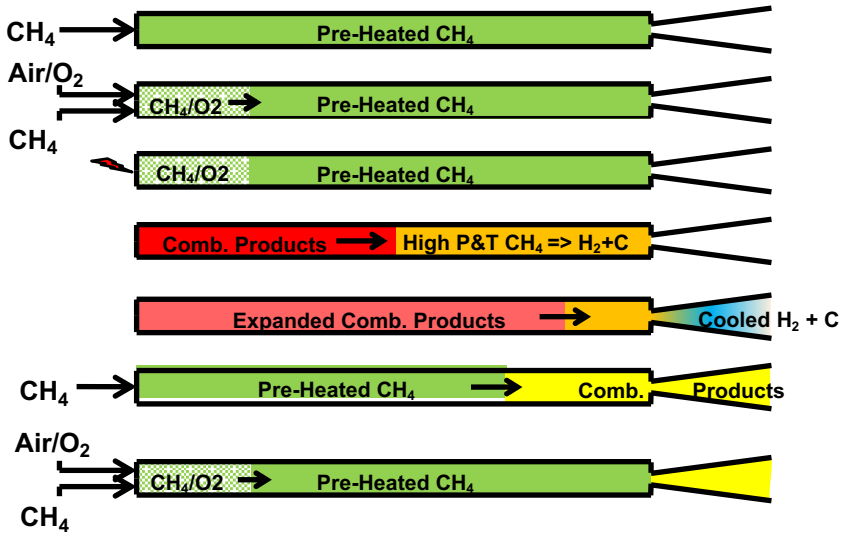
- *Abundant, inexpensive and continuous source feedstock*
- *Minimize CO2 Separation Costs*
- *Maximize Carbon Value*

# Tri-generation Pyrolysis (TGP)



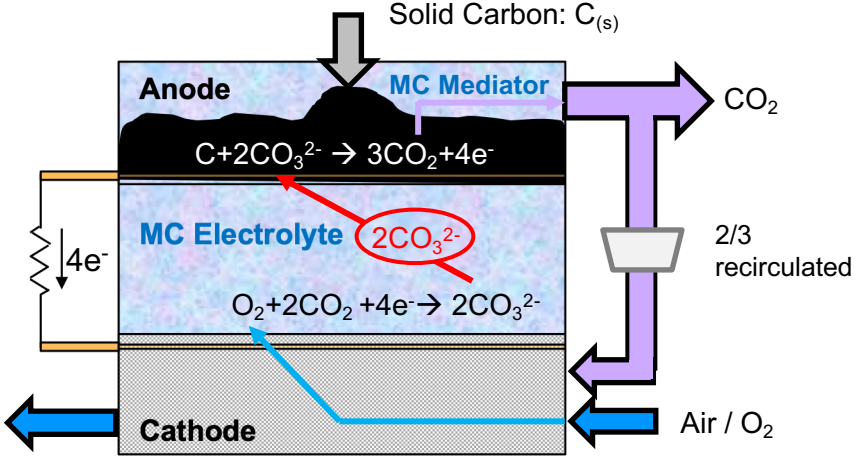
# Technology

## Pulse Methane Pyrolysis (PMP)




- Pulsed injection of thermal & mechanical energy
- Automatic removal of C-buildup due to unsteady flow
- Fast kinetics quenching via unsteady expansion
- Prototype reactor presently being assembled & tested
- PI Partners: Geminus Technologies, U of W, NRC

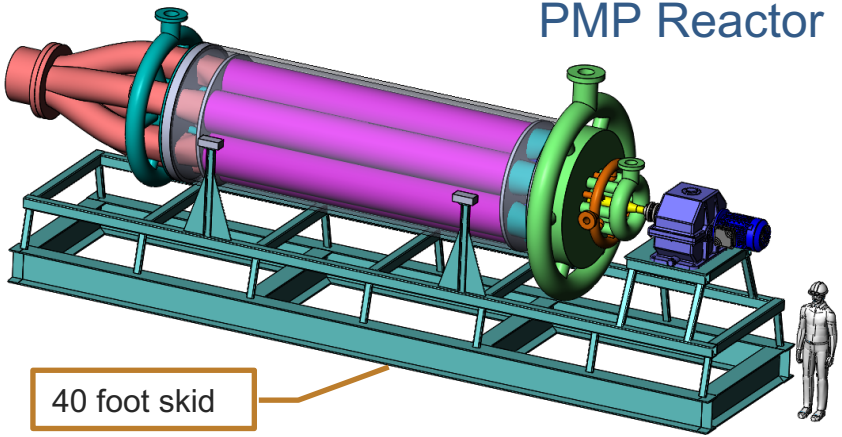
## Direct Carbon Fuel Cell (DCFC)




- Fuel: solid carbon in a MC mediator
- Advantages: high efficiency + pure CO2 byproduct
- Challenges: carbon delivery to anode
- Prototype *button cell* is presently being assembled & tested
- PI Partners: NRCan-Canmet Energy, NRC

# Preliminary Design

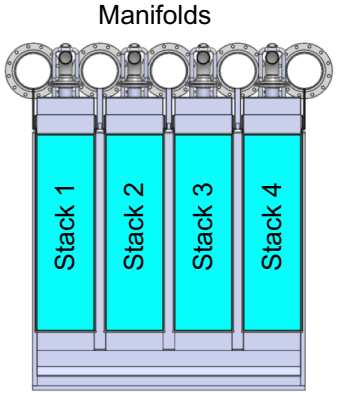
## PMP Reactor

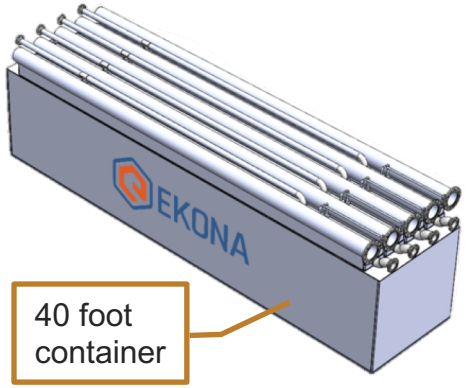



Capacity: **100 TPD-$H_2$, 366 TPD-carbon**

- Scalable for industrial applications
- Low cost reactor design
- Low maintenance / no carbon fouling
- Industry-standard balance of plant
- PMP H2 Production Cost: **~$10/GJ**

## DCFC Module



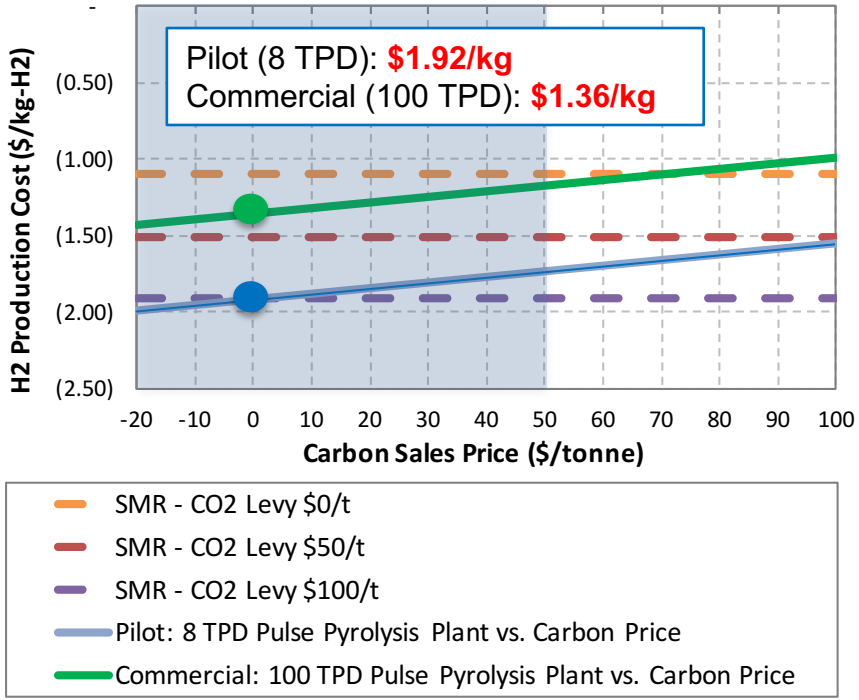

Capacity: **4 MWe (gross)**

- Containerized modules for site installation
- Industrial stack design for low-cost, industrial scale
- Low maintenance / electrolyte bath
- Pure CO2 byproduct (CCS / CCU)
- TGP H2 Production Cost: **~$5/GJ**

# H2 Production Cost

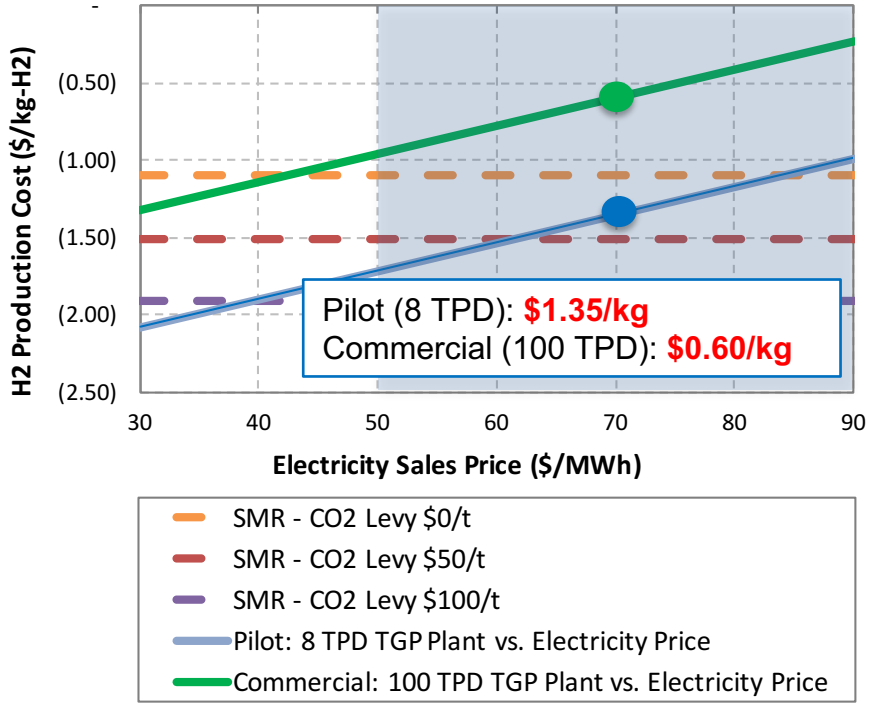
## Pulse Methane Pyrolysis (PMP)

*pyrolysis only w/o carbon sales*

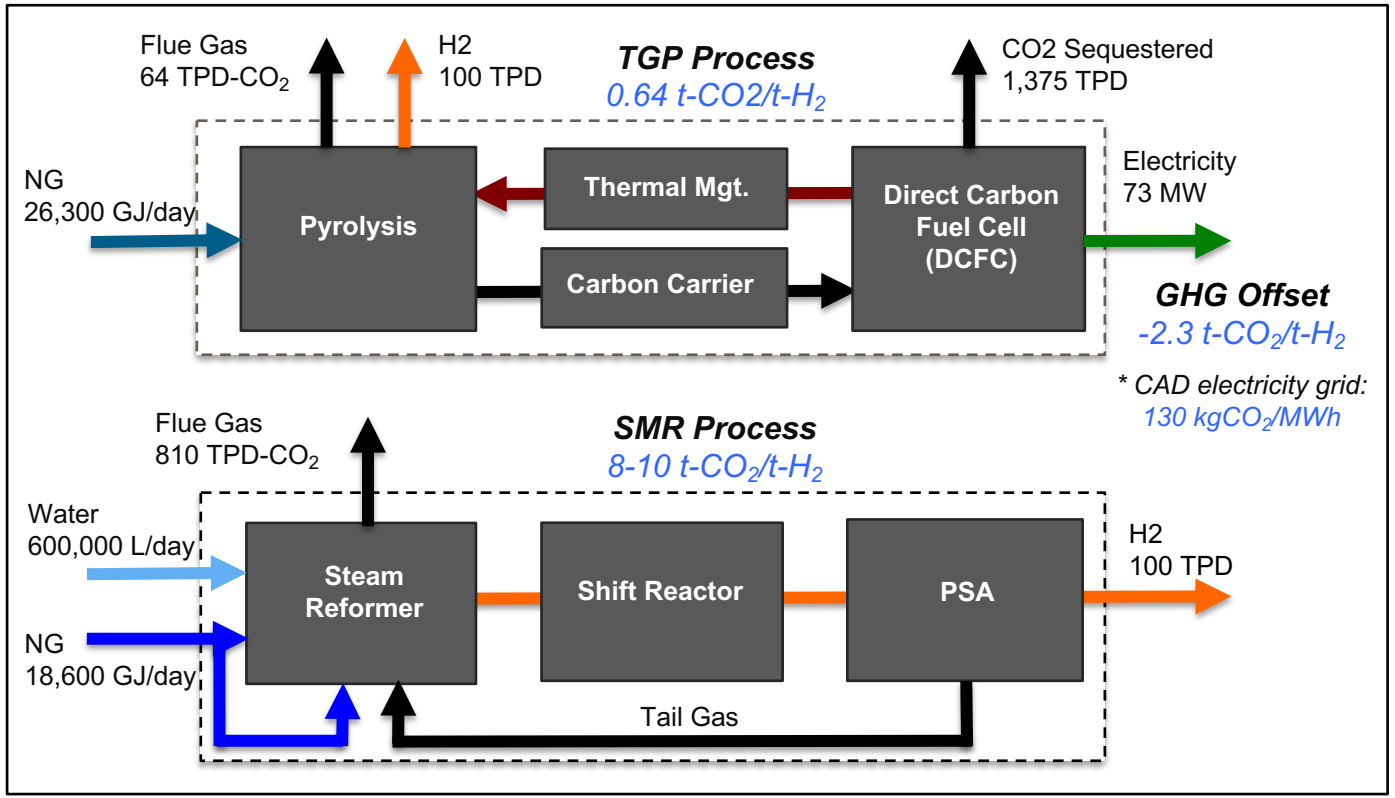



## Tri-generation Pyrolysis (TGP)

*includes DCFC for power generation*



# GHG Emissions




TGP versus SMR

- 90% GHG reduction
- 100% H2O reduction

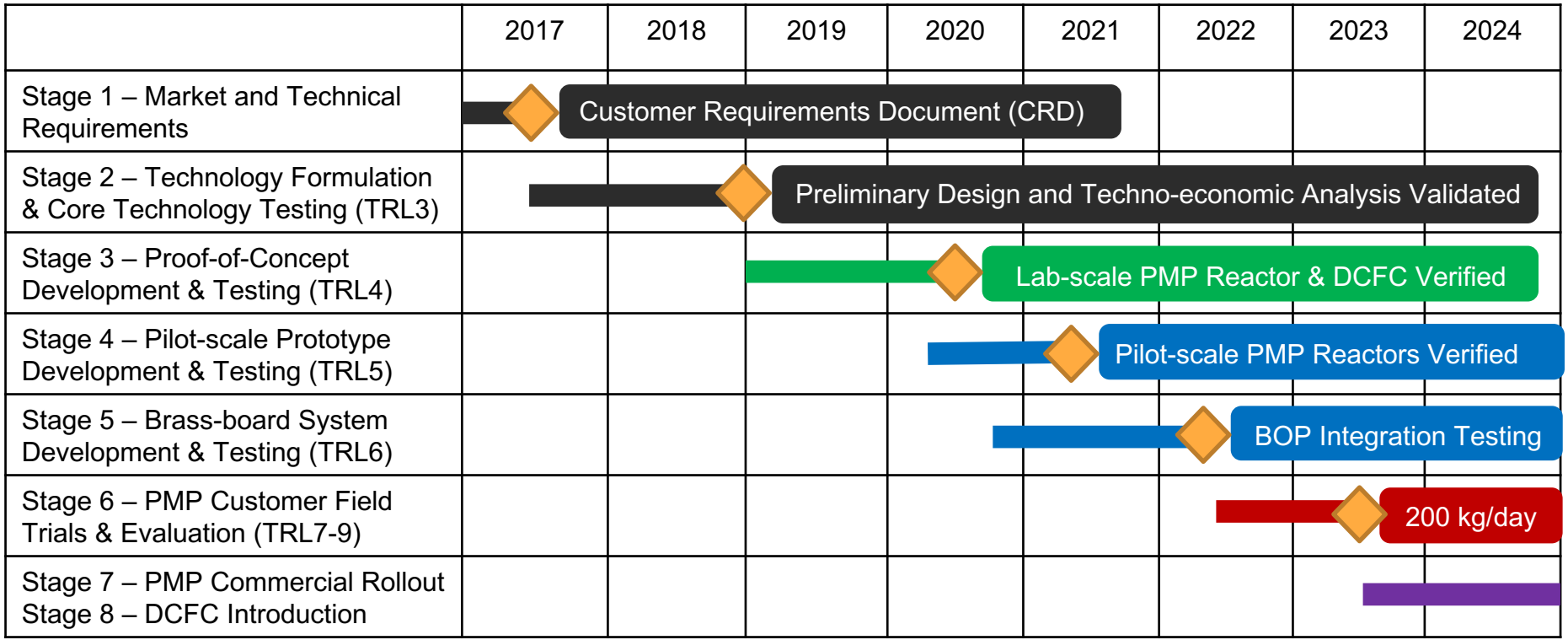
GHG Emissions Offset

- ~10 kg-$CO_2$/kg-$H_2$

GHG emissions reductions applied across all markets:

- Canada: 50 Mt-$CO_2$/year
  ~ 7% of Canada's GHGs
- Global: 1 Gt-$CO_2$/year
  ~ 2% of global GHGs

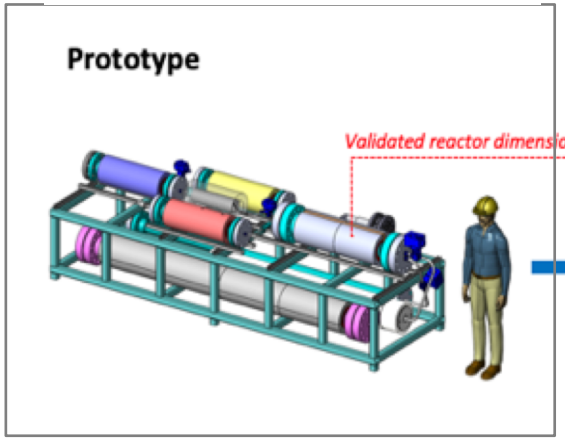
# Roadmap


2017
2018
2019
2020
2021
2022
2023
2024
Stage 1 – Market and Technical Requirements
Customer Requirements Document (CRD)
Stage 2 – Technology Formulation & Core Technology Testing (TRL3)
Preliminary Design and Techno-economic Analysis Validated
Stage 3 – Proof-of-Concept Development & Testing (TRL4)
Lab-scale PMP Reactor & DCFC Verified
Stage 4 – Pilot-scale Prototype Development & Testing (TRL5)
Pilot-scale PMP Reactors Verified
Stage 5 – Brass-board System Development & Testing (TRL6)
BOP Integration Testing
Stage 6 – PMP Customer Field Trials & Evaluation (TRL7-9)
200 kg/day
Stage 7 – PMP Commercial Rollout
Stage 8 – DCFC Introduction

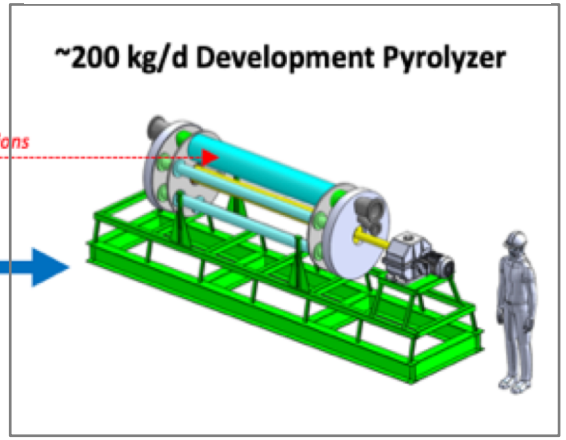
# PMP Field Trial Program

Field Testing of pyrolyzer system with lead customers is under development

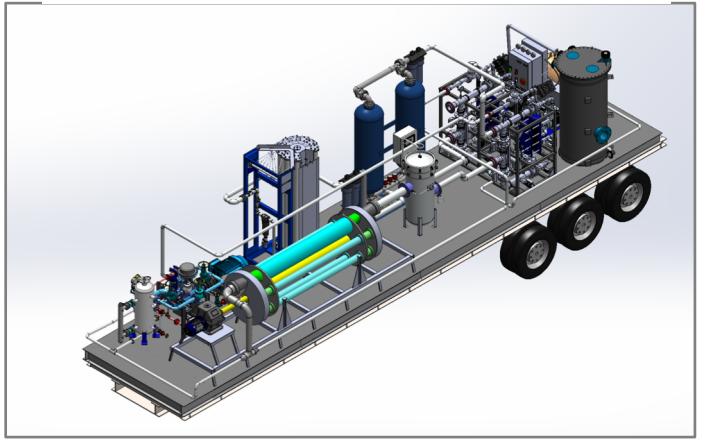
Lab-scale PMP Reactor Testing
2019-2020




Pilot-scale PMP Reactor Testing
2020-2021




PMP Field Trial Skid (~200 kg-H2/day)
2022-2023



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